3 / PRTS

10/534194

JC14 Rec'd PCT/PTO 06 MAY 2005

[10191/3672]

DOSING DEVICE

Background Information

The invention proceeds from a dosing device according to the species defined in the main claim.

In fuel-cell-assisted transport systems, so-called chemical reformers are used to recover the necessary hydrogen from hydrocarbon-containing fuels such as, for example, gasoline, ethanol, or methanol. Catalytic burners and secondary combustion devices are used to generate heat, especially during the cold-start phase.

All the substances required by the reformer for execution of the reaction, for example air, water, and fuel, are conveyed to the reaction region ideally in a gaseous or at least atomized state. But because water and the fuels, for example methanol or gasoline, are preferably present in liquid form on board the transport system, they must first be prepared shortly before they arrive at the reaction region of the reformer. This necessitates, for example, a dosing device which is capable of making the corresponding quantities of fuel or other substances available in finely atomized fashion.

The temperature necessary for the chemical reaction in which, for example, the fuel is reformed into hydrogen (inter alia) is made available by way of a so-called catalytic burner or secondary combustion device. Catalytic burners are components that have surfaces coated with a catalyst. In these catalytic burners, the fuel/air mixture is converted into heat and exhaust gases, the resulting heat being conveyed, for example via the enveloping surfaces and/or via the hot exhaust gas stream, to the

corresponding components such as the chemical reformer or an evaporator.

The conversion of fuel into heat is highly dependent on the size of the fuel droplets that strike the catalytic layer. The smaller the droplet size and the more uniformly the catalytic layer is wetted with the fuel droplets, the more completely the fuel is turned into heat and the higher the efficiency. The fuel is thus also converted more quickly, and pollutant emissions are reduced. Excessively large fuel droplets cause deposition on the catalytic layer and therefore slow conversion. That results, for example, in poor efficiency, especially during the cold-start phase.

Since the hydrogen is usually consumed immediately, chemical reformers must be capable of instantaneously adapting the production of hydrogen to demand, e.g. in the context of load changes or startup phases. Additional measures must be taken in the cold-start phase in particular, since the reformer is not supplying any waste heat. Conventional evaporators are not capable of instantaneously generating the corresponding quantities of gaseous reactants.

It is therefore useful to distribute the fuel with good preparation by way of a dosing device in finely distributed form and/or with good placement onto locations and surfaces on which the fuels can properly evaporate, for example into the reaction chamber or the premixing chamber of a reformer or catalytic burner, the internal surfaces of a cylindrical combustion chamber, or the internal enveloping surfaces of a catalytic burner. It is additionally useful to be able to adapt the fuel cloud, in terms of its geometric shape, propagation speed, and swirl formation, to the combustion chamber and to the conditions prevailing therein.

Apparatuses for dosing fuels into reformers are known, for example, from U.S. Pat. No. 3,971,847. Here the fuel is fed in, by metering

devices relatively remote from the reformer, through long metering conduits and a single nozzle into a temperature-controlled material stream. The fuel first strikes impact panels that are disposed after the outlet opening of the nozzle and are intended to cause turbulence in and distribution of the fuel, and then enters the reaction region of the reformer through a relatively long evaporation section that is necessary for the evaporation process. The long metering conduit allows the metering device to be insulated from thermal influences of the reformer.

A particular disadvantage of the apparatuses known from the aforementioned document is the fact that below the operating temperature of the reformer, for example in a cold-start phase, atomization of the fuel is only insufficiently achieved, and the dosing device is of very complex and bulky design. Because of the resulting relatively small reaction surface between fuel and oxidizer, the chemical reaction or combustion occurs only slowly, and usually also incompletely. Efficiency greatly decreases as a result, and pollutant emissions rise disadvantageously. Incomplete combustion or an incomplete chemical reaction usually results in the formation of aggressive chemical components that can damage the chemical reformer or secondary combustion device and to deposits that can impair functionality. The complex and bulky design in the nozzle region, where atomization takes place, results in high manufacturing and operating costs especially as a consequence of more difficulty in assembly and greater error susceptibility.

In particular, the propagation speed, geometrical shape, and swirl formation of the fuel cloud generated by the nozzle and impact panels can be influenced only in very inadequate fashion.

Advantages of The Invention

The dosing device according to the present invention having the characterizing features of the main claim has, in contrast, the advantage that atomization and distribution of the fuel or the fuel/gas mixture is substantially improved. In particular, the propagation speed, swirl formation, and geometrical shape of the fuel cloud or fuel/gas mixture cloud in the combustion chamber or dosing chamber can advantageously be determined. As a result, for example, the cold-start phase can be substantially shortened, and the efficiency of the secondary combustion device or chemical reformer can be greatly increased already during the cold-start phase. Pollutant emissions are substantially reduced. The dosing device according to the present invention moreover makes it possible to manufacture the dosing device in very simple, reliable, and therefore economical fashion. In addition, standardized components produced on a series basis can be used.

The features set forth in the dependent claims make possible advantageous refinements of the dosing device described in the main claim.

In a first refinement of the dosing device according to the present invention, the nozzle body has an upstream supply tube and a downstream support element, both being of tubular, in particular cylindrically tubular shape and being connected to one another in hydraulically sealed fashion by welding or laser welding. As a result, both parts can be manufactured easily and thus economically, and can each be economically manufactured separately in accordance with the particular requirement.

In a further advantageous refinement, the swirl insert is joined in hydraulically sealed fashion to the support element, in particular by pressing, welding, or laser welding. Particularly strong, reliable, and economical joins can thereby be produced.

It is additionally advantageous if the swirl insert has at least one seat element having a spray discharge opening, and a swirl element. The parts of the swirl insert can thus be easily and economically adapted to different loads and conditions.

It is furthermore advantageous to embody the swirl element in disk form. As a result, it can be machined particularly easily. In addition, the swirl element advantageously has a continuous opening through which swirl development and swirl formation can advantageously be influenced.

The dosing device according to the present invention can furthermore be refined in that the swirl element is joined to the seat element by welding or laser welding. Economical manufacturing steps and reliable and strong joins can thereby be achieved.

It is also advantageous to dispose an intermediate element between the swirl element and the seat element. The swirl element can thereby be spaced away from the seat element so as thereby advantageously to influence the swirl properties.

The swirl element is advantageously disposed with a spacing from the wall of the support element. As a result, fuel inflow into the swirl element can be accomplished without hindrance and can also occur from the side of the wall of the support element in order, in particular, to enhance swirl formation.

Advantageously, the opening of the swirl element is at least partially closed off with an insert. The swirl properties can thus be further improved and adapted to particular conditions and requirements. Advantageously, the insert is also connected to the swirl element by welding or laser welding.

The opening moreover has a longitudinal opening axis that has a directional component lying in the flow direction of the fuel or the fuel/gas mixture.

The swirl element advantageously has at least one swirl conduit that has a directional component radial and tangential to the longitudinal opening axis.

The metering conduit and the metering device are advantageously joined in hydraulically sealed and detachable fashion by way of an adapter, thus enhancing ease of assembly.

In a further refinement, the adapter connecting the metering conduit and the metering device has an air inlet, the air inlet being connected in the adapter to the metering conduit. As a result, mixture preparation can already be initiated in the metering conduit, the fuel and/or gas fed into the metering line being mixed with air. The result is an overall improvement in the atomization and mixture preparation of fuel and/or the metered-in gas with air. In addition, undesired fuel or gas residues can be eliminated from the metering line as a result of the air delivery, by being blown out with, for example, air through the air inlet, for example before a stop phase or idle phase. Uncontrolled discharge of fuel into the metering chamber or the environment can thus be prevented.

A fuel injection valve, such as the one used e.g. for reciprocating-piston machines with internal combustion, is advantageously utilized as the metering device. The use of such valves has several advantages. For example, they permit particularly accurate open- or closed-loop control of fuel metering, in which context the metering can be controlled by way of several parameters such as pulse duty factor, clock frequency, and optionally stroke length. The dependency on pump pressure is much less pronounced than in the case of metering devices that

control the volumetric flow of the fuel by way of the conduit cross section, and the dosing range is much larger.

In addition, fuel injection valves are economical, reliable components that have proven successful in many ways, are known in terms of their behavior, and are chemically stable with respect to the fuels used; this is true in particular of so-called low-pressure fuel injection valves that can be used with advantage here because of the thermal decoupling resulting from the metering conduit.

The metering conduit advantageously has a number of reduced-wall-thickness points that decrease the thermal conductivity of the metering conduit and can also serve as heat sinks.

The multi-part construction of the dosing device makes possible economical manufacture and the use of standardized components.

Drawings

Exemplary embodiments of the invention are depicted in simplified fashion in the drawings and explained in more detail in the description below. In the drawings:

Figure 1 schematically depicts a first exemplary embodiment of a dosing device according to the present invention;

Figure 2 schematically depicts, in section, the nozzle body of the first exemplary embodiment;

Figure 3 schematically depicts a swirl element of the first exemplary embodiment;

Figure 4 schematically depicts, in section, the nozzle body of a second exemplary embodiment; and

Figure 5 schematically depicts, in section, the nozzle body of a third exemplary embodiment.

Description of The Exemplary Embodiments

Exemplary embodiments of the present invention are described below by way of example. The exemplary embodiments of the dosing device that are shown are suitable in particular for preparing and dosing liquid fuels and air into a hollow cylinder of a chemical reformer or a secondary combustion device with a spray angle of less than 60°.

An exemplary embodiment of a dosing device 1 according to the present invention depicted in Figure 1 is embodied in the form of a dosing device 1 for the use of low-pressure fuel injection valves. Dosing device 1 is suitable in particular for the input and atomization of fuel or a fuel/gas mixture into a metering chamber (not depicted) of a chemical reformer (not depicted in further detail) in order to recover hydrogen, or of a secondary combustion device (not depicted in further detail) in order to generate heat.

Dosing device 1 encompasses a metering device 2 which in this exemplary embodiment is embodied as a low-pressure fuel injection valve, an adapter 6 for receiving metering device 2 and a tubular metering conduit 8 that is e.g. 10 to 100 cm long, an air inlet 9, and a nozzle body 7. Metering device 2 is tubular and has a fuel connector 13 on its upper side. At the side, metering device 2 has an electrical connector 5. Metering of fuel or a fuel/gas mixture into metering conduit 8 is accomplished on the lower side of metering device 2, adapter 6 connecting metering device 2 and metering conduit 8 to one another in an externally hydraulically

sealed manner. Tubular air inlet 9 opens into adapter 6 and is thus in communication with metering conduit 8.

The hollow-cylindrical end of nozzle body 7 facing toward metering conduit 8 is connected in hydraulically sealed fashion to metering conduit 8 via a first connecting element 10.1 of hollow cylindrical shape. Metering conduit 8 itself is made up, for example, of a standardized metal tube made of stainless steel. In this exemplary embodiment, metering conduit 8 is embodied in two parts, the part of metering conduit 8 facing toward adapter 6 being connected by way of a second connecting element 10.2 to the part of metering conduit 8 facing toward nozzle body 7.

The lower part of metering device 2 engages into adapter 6 and is connected in hydraulically sealed fashion to adapter 6 by way of a mounting element 3 in the form of a clamp.

Nozzle body 7 has, in its spray-discharge end facing away from metering conduit 8, a swirl insert 24 that is depicted in Figure 2 and has at least one spray discharge opening 14.

Fuel, for example gasoline, ethanol, or methanol, is conveyed to metering device 2 under pressure from a fuel pump and fuel line (not depicted) through fuel connector 13 located on the upper side of metering device 2. When dosing device 1 is in operation, the fuel flows downward and is metered, through the sealing fit (not depicted) located in the lower end of metering device 2, into metering conduit 8 in known fashion by opening and closing the sealing fit. Air or other gases, for example combustible residual gases from a reforming or fuel-cell process, can be conveyed, for mixture preparation, through air inlet 9 that opens through adapter 6 into metering conduit 8. As it continues, the fuel or fuel/gas mixture flows through metering conduit 8 to nozzle body 7 and is there metered in swirled fashion, through spray discharge opening 14 depicted in Figure 2, into the metering chamber (not depicted).

Air can also be conveyed through air inlet 9 for controlled emptying of metering conduit 8, for example shortly before an idle or stop phase.

As a result of metering conduit 8, metering device 2, in particular the sealing fit (not depicted) of metering device 2 that is sensitive to high temperatures and large temperature fluctuations, is thermally decoupled from the temperatures in the metering chamber (not depicted), which are e.g. 500°C. The length, material, and shape of metering conduit 8 are selected, in particular, in accordance with thermal and physical conditions. Metering conduit 8 can also, preferably, have reduced-wall-thickness points that can contribute to thermal insulation or act as heat sinks.

Figure 2 schematically depicts, in section, nozzle body 7 of the first exemplary embodiment. Nozzle body 7 is made up of a support element 15, a supply tube 17, and swirl insert 24 disposed downstream in support element 15. All three aforesaid components 15, 17, 24 are cylindrical and are oriented concentrically on a longitudinal nozzle body axis 11 of nozzle body 7.

Supply tube 17, which is connected to metering conduit 8 (shown in Figure 1) by way of first connecting element 10.1, is joined at its downstream end, in hydraulically sealed fashion, to support element 15 by way of a first weld seam 18 that is produced by laser welding. The join can also be implemented, however, by pressing, soldering, welding, or a threaded connection.

Swirl insert 24, located in the lower, downstream end of support element 15, encompasses a seat element 4 having spray discharge opening 14 disposed centeredly therein and a swirl element 16 having swirl conduits 12 and a centeredly disposed opening 25. Seat element 4 and swirl element 16 are each embodied in a disk shape. The downstream-facing disk underside of swirl element 16, and the

upstream-facing upper disk side of seat element 4, rest against each other via an intermediate element 22 and are joined to one another with a fourth weld seam 21 that is produced by a laser welding method. Intermediate element 22 spaces seat element 4 and swirl element 16 apart. A distance 27 is present between the walls of support element 15 and the sides of swirl element 16 that face toward the wall of support element 15.

In this exemplary embodiment, longitudinal opening axis 26 of opening 25 is coincident with longitudinal nozzle body axis 11. Discharge opening 14 in seat element 4 is disposed concentrically with both axes 26, 11. In this exemplary embodiment, a peg-shaped or cylindrical insert 28 engages through opening 25 of swirl element 16 and closes off opening 25. The downstream end of insert 28 does not, however, rest against seat element 4. As a result, the fuel or fuel/gas mixture can arrive at spray discharge opening 14, located downstream from swirl element 16, only through swirl conduits 12 disposed in swirl element 16. Insert 28 is mounted in hydraulically sealed fashion on swirl element 16, along its outer circumference against the upper disk side of swirl element 16, by way of a third weld seam 20.

Swirl insert 24 is mounted in hydraulically sealed fashion on seat element 4 on support element 15 by way of a second weld seam 19 that is produced using a laser welding method, second weld seam 19 extending approximately along the outer circumference of seat element 4.

Figure 3 schematically depicts a swirl element 16 of the first exemplary embodiment, from a point located upstream along longitudinal opening axis 26. The four swirl conduits 12 extend in the circular and disk-shaped swirl element 16 with a radial and tangential directional component with respect to longitudinal opening axis 26 of opening 25. The fuel or fuel/gas mixture enters swirl conduits 12 at the upstream upper disk side of swirl element

16 close to the outer circumference of swirl element 16 and at the sides of swirl element 16. The fuel or fuel/gas mixture is then directed, within swirl element 16, through swirl conduits 12 to the centeredly located opening 25, where the fuel emerges in swirled fashion on the lower disk side of swirl element 16 close to opening 25, and flows to spray discharge opening 14 shown in Figure 2.

Figure 4 is a schematic sectioned depiction of nozzle body 7 of a second exemplary embodiment of dosing device 1 according to the present invention, similar to that of the first exemplary embodiment of Figure 2. In contrast to the exemplary embodiment of Figure 2, however, intermediate element 22 is substantially absent. In addition, seat element 4 belonging to swirl insert 24 has several spray discharge openings 14 having different inclination angles.

Intermediate element 22 used to space swirl element 16 and seat element 4 apart is replaced by a recess 29 disposed centeredly in the upstream upper disk side of seat element 4, swirl element 16 resting on ring 30 thereby created on the upper disk side of seat element 4.

Figure 5 is a schematic sectioned depiction of nozzle body 7 of a third exemplary embodiment of dosing device 1 according to the present invention, this exemplary embodiment being very similar to that of Figure 4. In contrast to the second exemplary embodiment of Figure 4, however, insert 28 is absent. The fuel or fuel/gas mixture can thus flow through opening 25 and swirl conduits 12 to spray discharge openings 14.